Radiological studies during the ALBA Linac commissioning

ALBA Safety Group:

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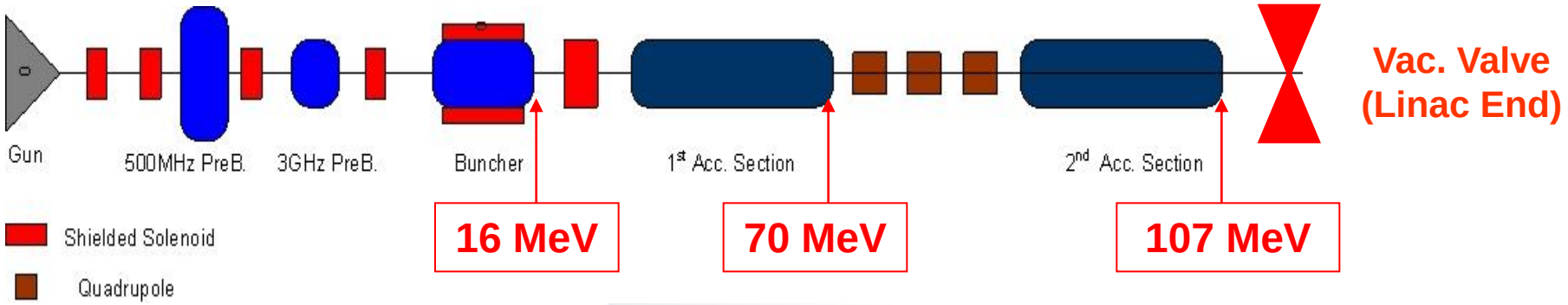
INTRODUCTION

- 4 months commissioning: June'08-October'08
- Using temporal electrical & water cooling services
- 2 operational modes: single and multibunch
- Maximum beam energy: 107 MeV
- Influence of 2 main components: BM and Cu scrapper
- First radiation measurement for the ALBA linac
- First test of the PSS and radiation monitor network
- 3 types of radiation measurement: passive, portable and on-line network

1a. Machine description: RF

ALBA LINAC RF COMPONENTS *(Thales manufacturer)*



- Electron Gun : Thermoionic (Pierce type), 90 kV DC gun with grid modulator at 500 MHz

- Bunching Section: Prebuncher: single cell @ 500MHz
  Prebuncher: single cell @ 3 GHz
  Buncher: 1 SW bunching section @ 3GHz
  Energy at the bunching section output = 16 MeV
  Low electron losses

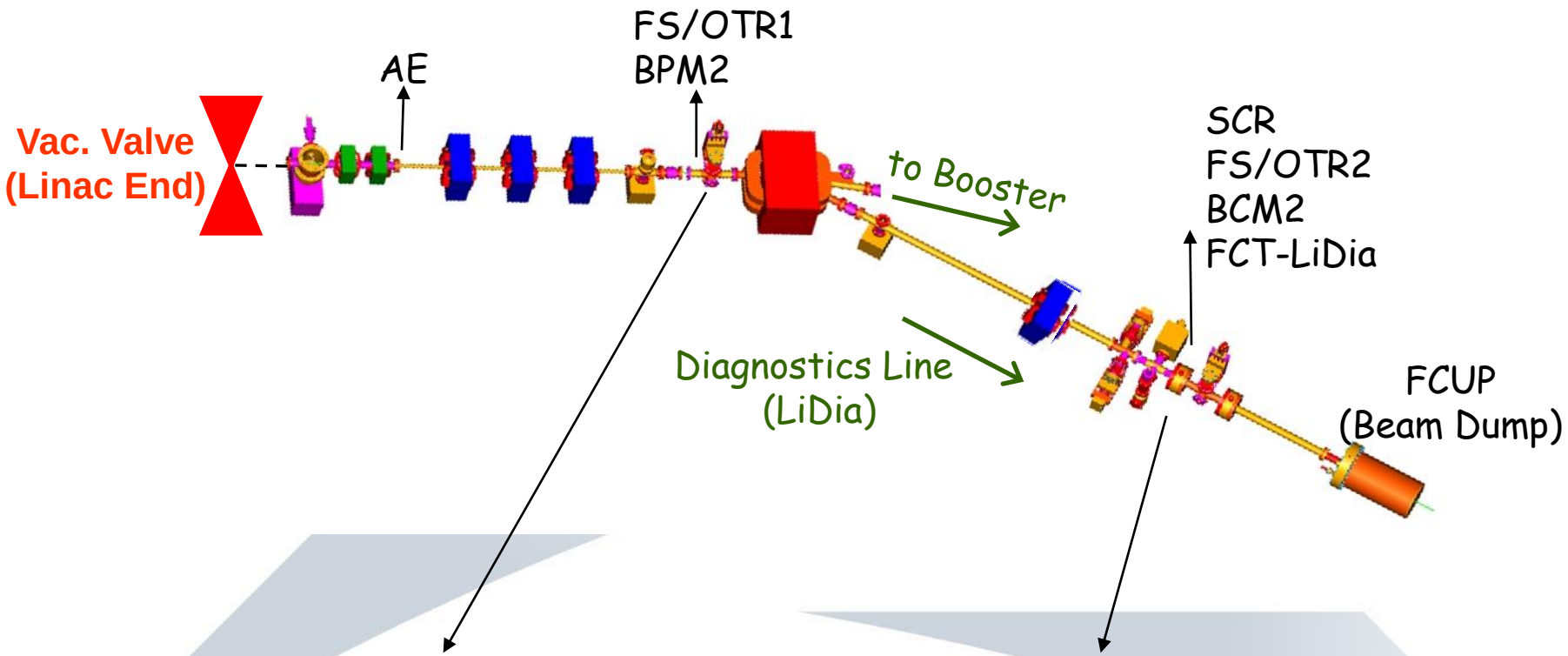
- 2 ACCEL. SECTIONS: Energy gain= 55 MeV @ 20MW nominal input power.

- 2 Klystron modulators: 35MW each klystron at 3GHz.
  The first one feeds the 3GHz bunching section and the 1st acc.structure.
  The second one feeds the second accelerating structure

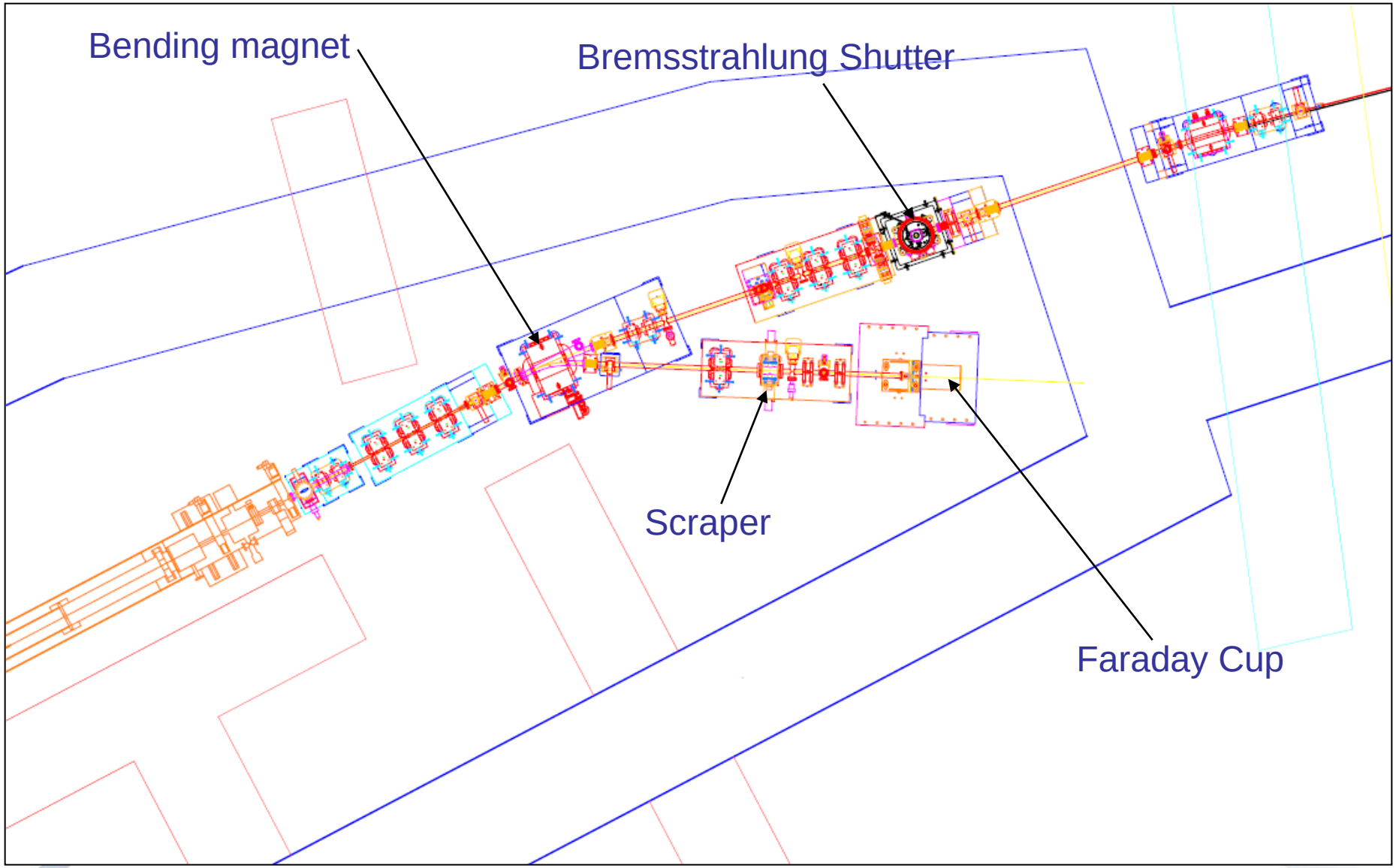
1a. Machine description

1a. Machine description

ALBA LTB MAGNETS and DIAGNOSTIC COMPONENTS
(designed & installed by ALBA)



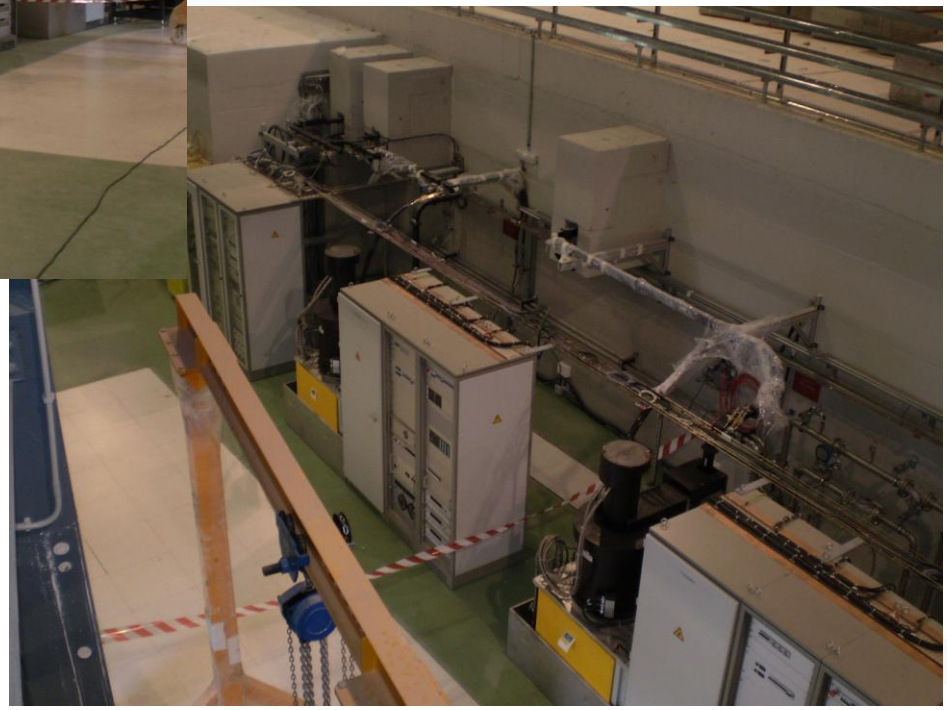
1a. Machine description



1a. Machine description

1a. Machine description: Service Area

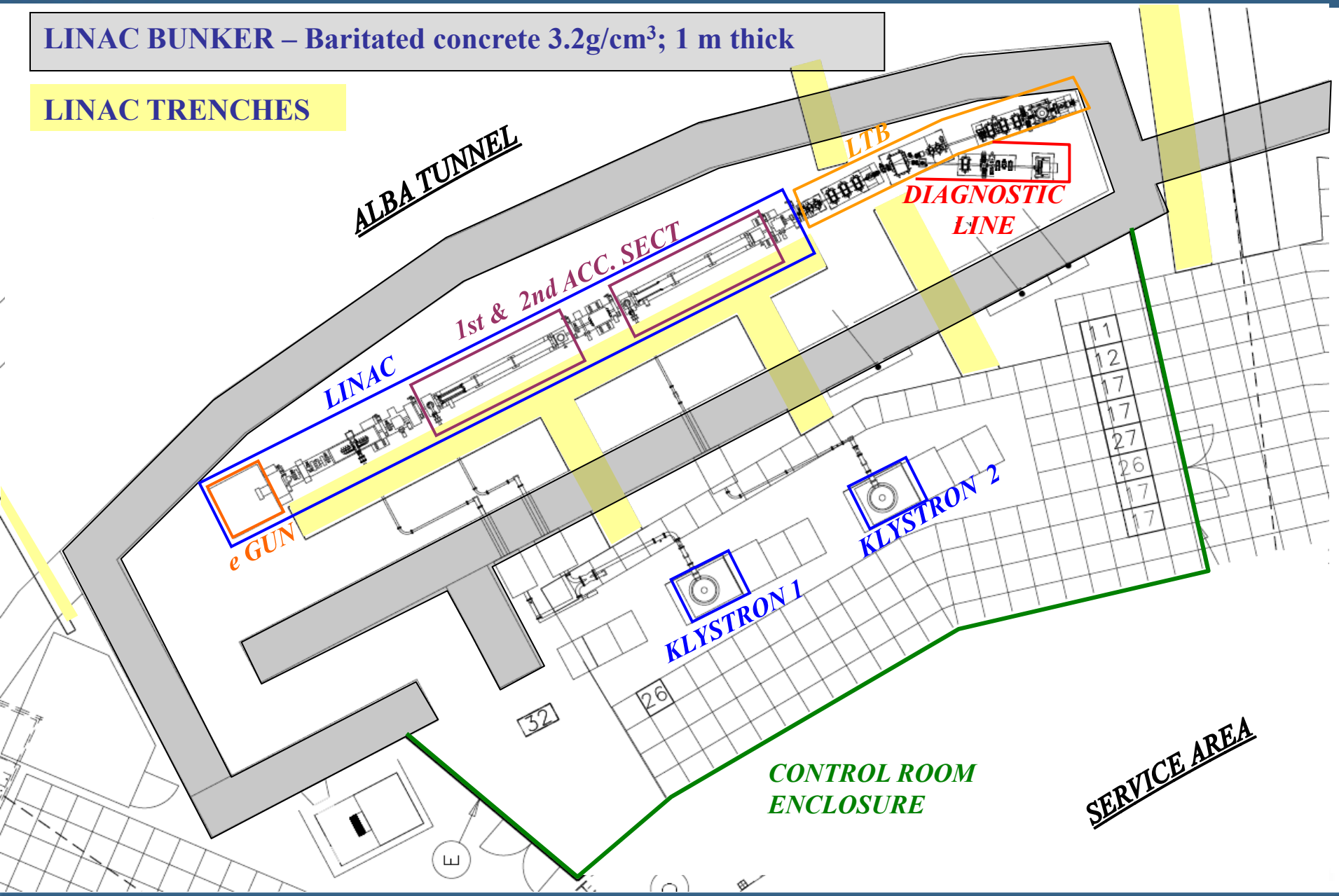
ALBA linac entrance and control: present configuration



1b. LINAC vault

LINAC BUNKER – Baritated concrete 3.2g/cm^3; 1 m thick

LINAC TRENCHES



1b. LINAC vault

1c. Commissioning results: beam specs

Multibunch Mode ALBA Linac Parameters:

Parameter	Specs	Measured
Pulse length	0.3 to 1μs	0.112 μs (*)
Charge	≥3nC (in 1 μs)	4 nC
Energy	≥100MeV	107 MeV
Pulse to pulse energy variation	≤0.25 % (rms)	0.06 % (rms)
Relative energy spread	≤0.5 % (rms)	0.23 % (rms)
Norm. Emittance (1σ)	≤30 π mm mrad (both planes)	< 25 π mm mrad (both planes)
Pulse to pulse time jitter	≤100ps (rms)	25 ps (rms)
Repetition rate	3 to 5 Hz	1-3 Hz (**)

(*) Optimum length according to Beam Dynamics Simulation is 112 ns
(**) **Tested at 1 and 3 Hz**

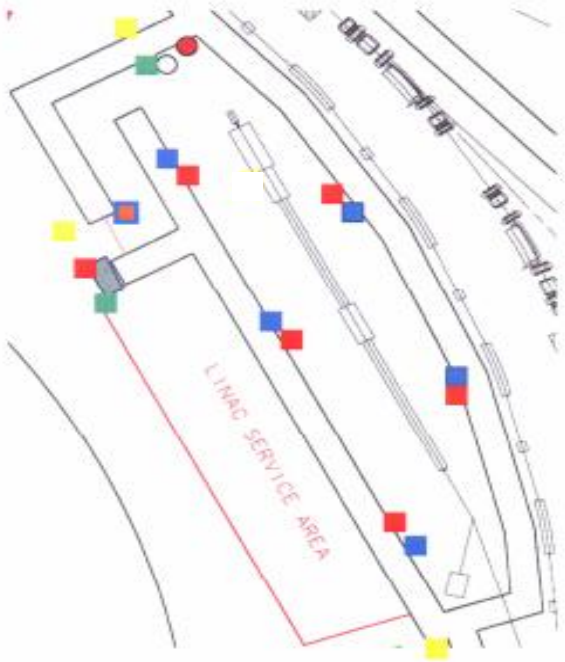
1c. Commissioning results: beam specs

Single bunch Mode ALBA Linac Parameters:

Parameter	Specs	Measurements
Pulse length	1ns (FWHM)	0.4 ns
Charge	≥1.5nC	2 nC
Energy	≥100MeV	107 MeV
Pulse to pulse energy variation	≤0.25 % (rms)	0.08 % (rms)
Relative energy spread	≤0.5 % (rms)	0.28 % (rms)
Norm. Emittance (1σ)	≤30 π mm mrad (both planes)	< 25 π mm mrad (both planes)
Single bunch purity	Better than 1%	< 2 %
Pulse to pulse time jitter	≤100ps (rms)	25 ps (rms)
Repetition rate	3 to 5 Hz	1-3 Hz (**)

(**) Tested at **1 and 3 Hz**

2. PSS overview

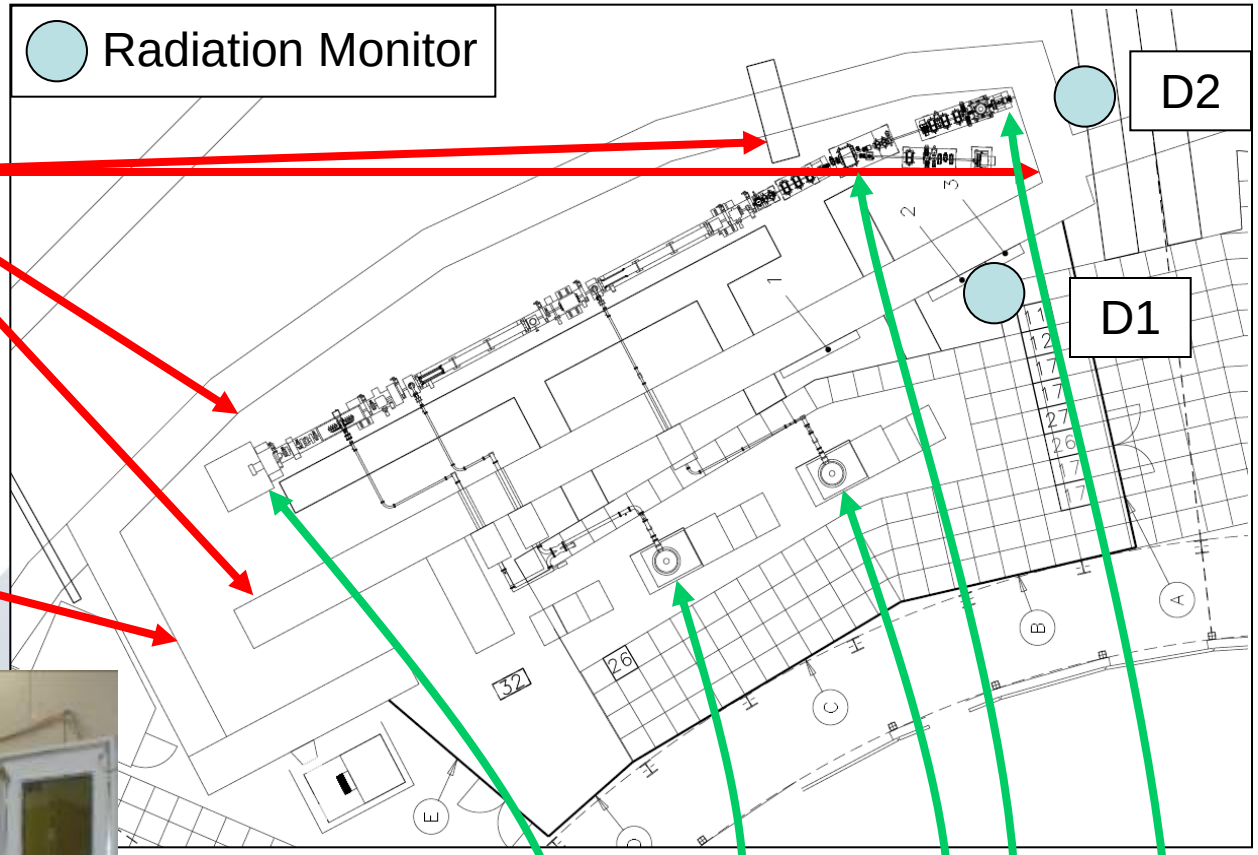


PSS-LINAC components:

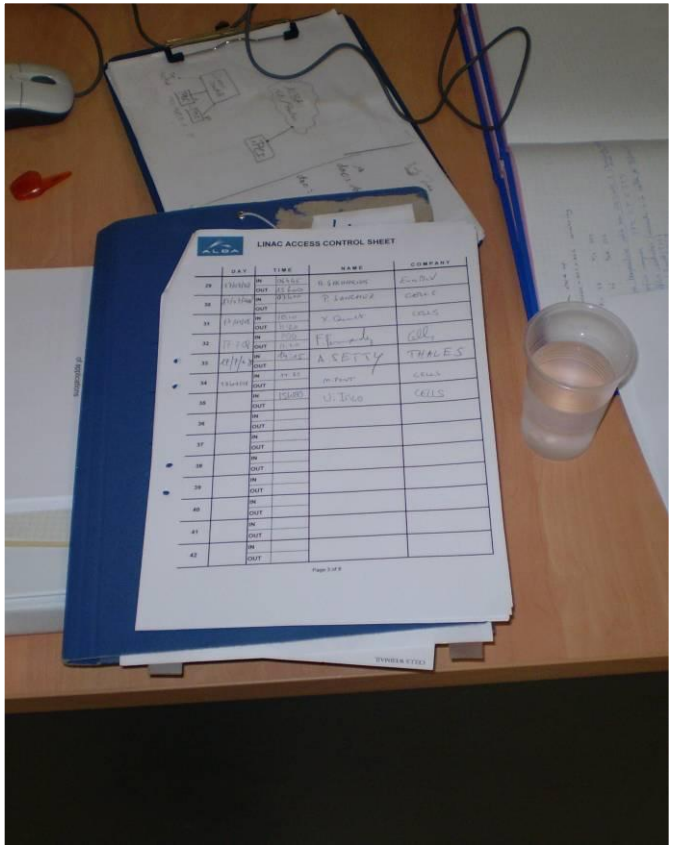
- PLC-SIL3 technology
- Acts on:
  - e-Gun
  - RF
  - BS Shutter
- Pilz manufacturer

	PLC	**1**
	Pulsador de patrulla "Search button"	5+2
	Seta de emergencia	6
	Puerta	1
	Armario principal del PSS con botones y paneles de llaves	1
	Sirena y luz intermitente	1
	Paneles luminosos : BEAM ON, OPEN, RESTRICTED, INTERLOCKED	2
	Monitor de radiación	4 (not included)
	Pulsador para abrir la puerta desde dentro	1
	Altavoz	1
	Salidas para matar el haz de electrones	4

2a. PSS: Access control



2a. PSS: Access control



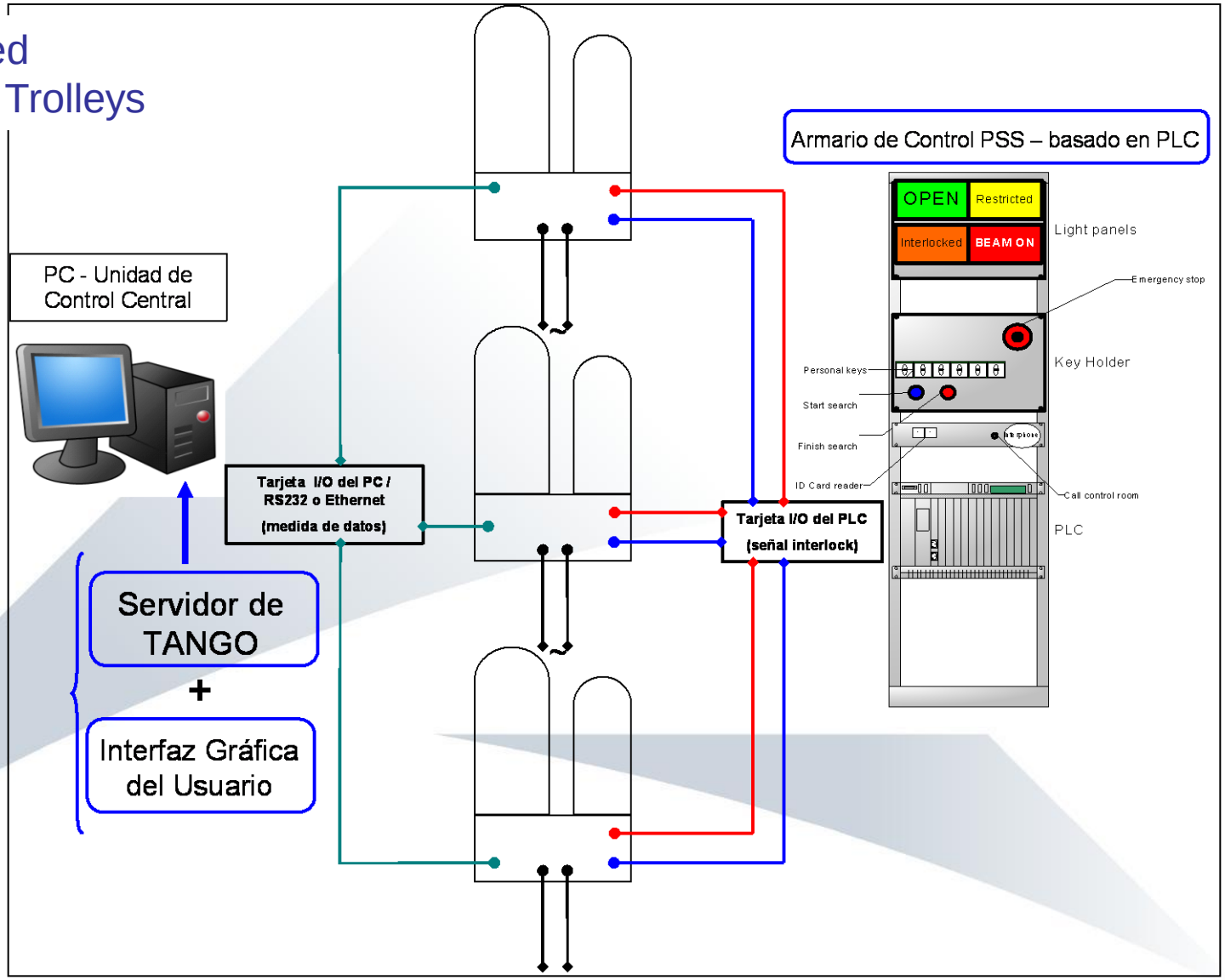
2b. PSS: Radiation Monitors Network

Radiation Monitor Network (19 + 4 + 1 Fixed; 3 + 3 + 3 on trolleys: TOTAL 33):

For linac: 1 + 1 Fixed
2 + 2 + 1 Trolleys

Accumulated dose (4 hours): < 2.0 µSv

If > 2.0 µSv: LINAC stopped (electron gun & RF)



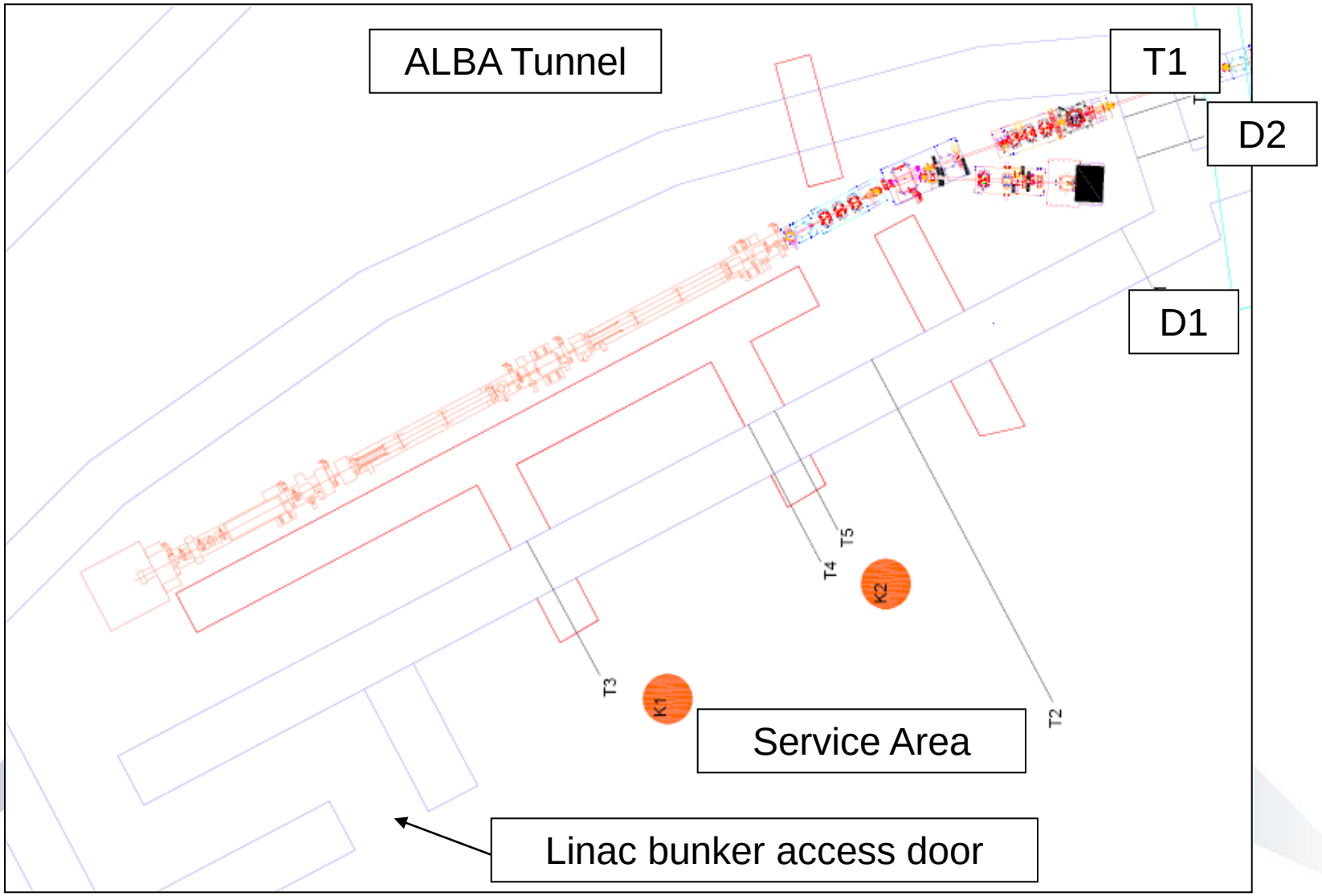
2b. PSS: Radiation Monitors Network

Dose Rate

Accumulated dose

2b. PSS: Radiation Monitors Network

Fixed detector distribution (D1 y D2) and Trolleys (T1, T2, T3, T4 y T5)



3. RADIOLOGICAL MEASUREMENTS

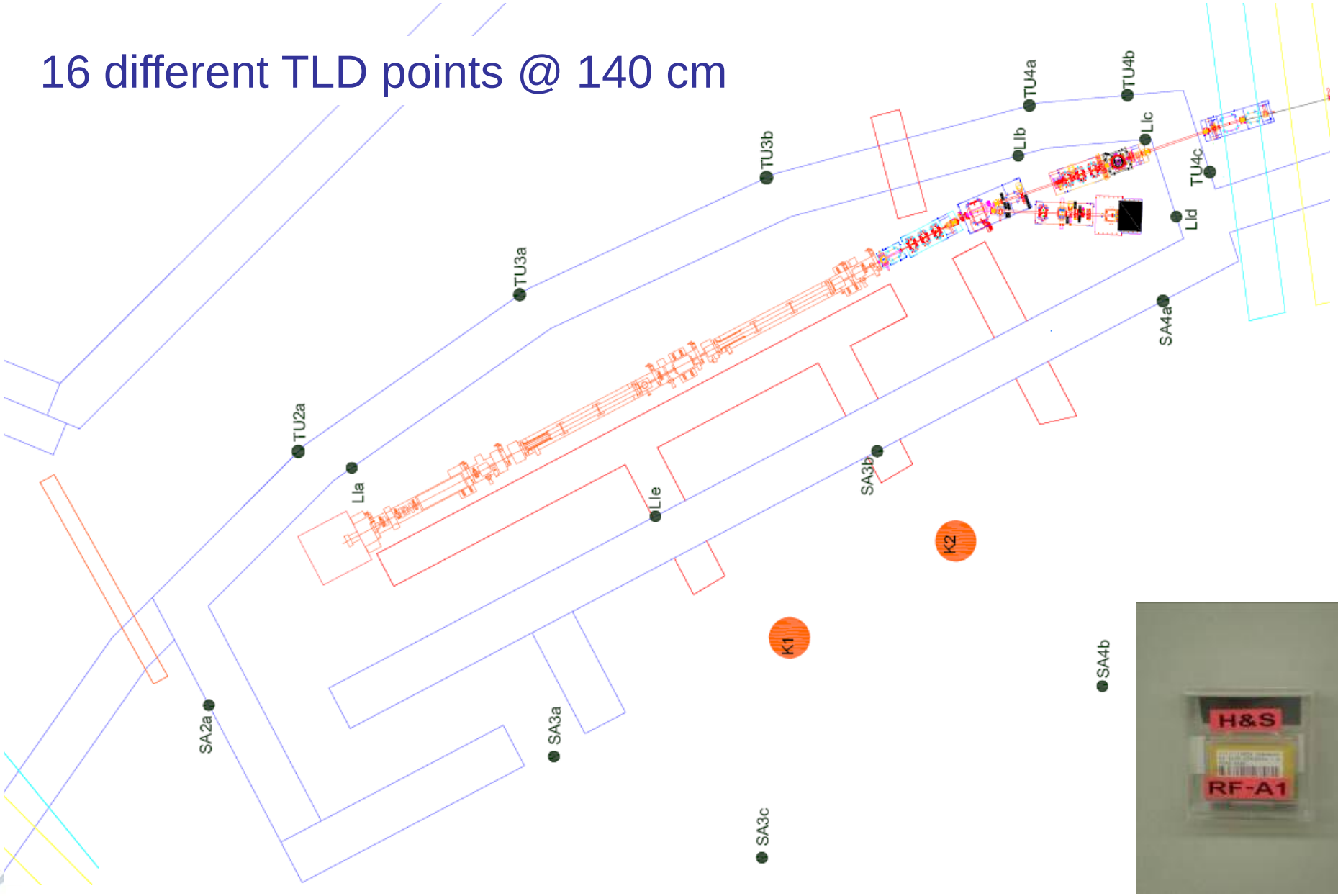
a. Passive Detectors: TLD (IN & OUT)

b. Portable Detectors
   - Survey: OUT
   - Activation: IN
   - Spectrometer: IN

c. Radiation Monitors Network (OUT)
   - Bending Magnet scans
   - Scrapper aperture scans

3a. TLD LOCATION

16 different TLD points @ 140 cm



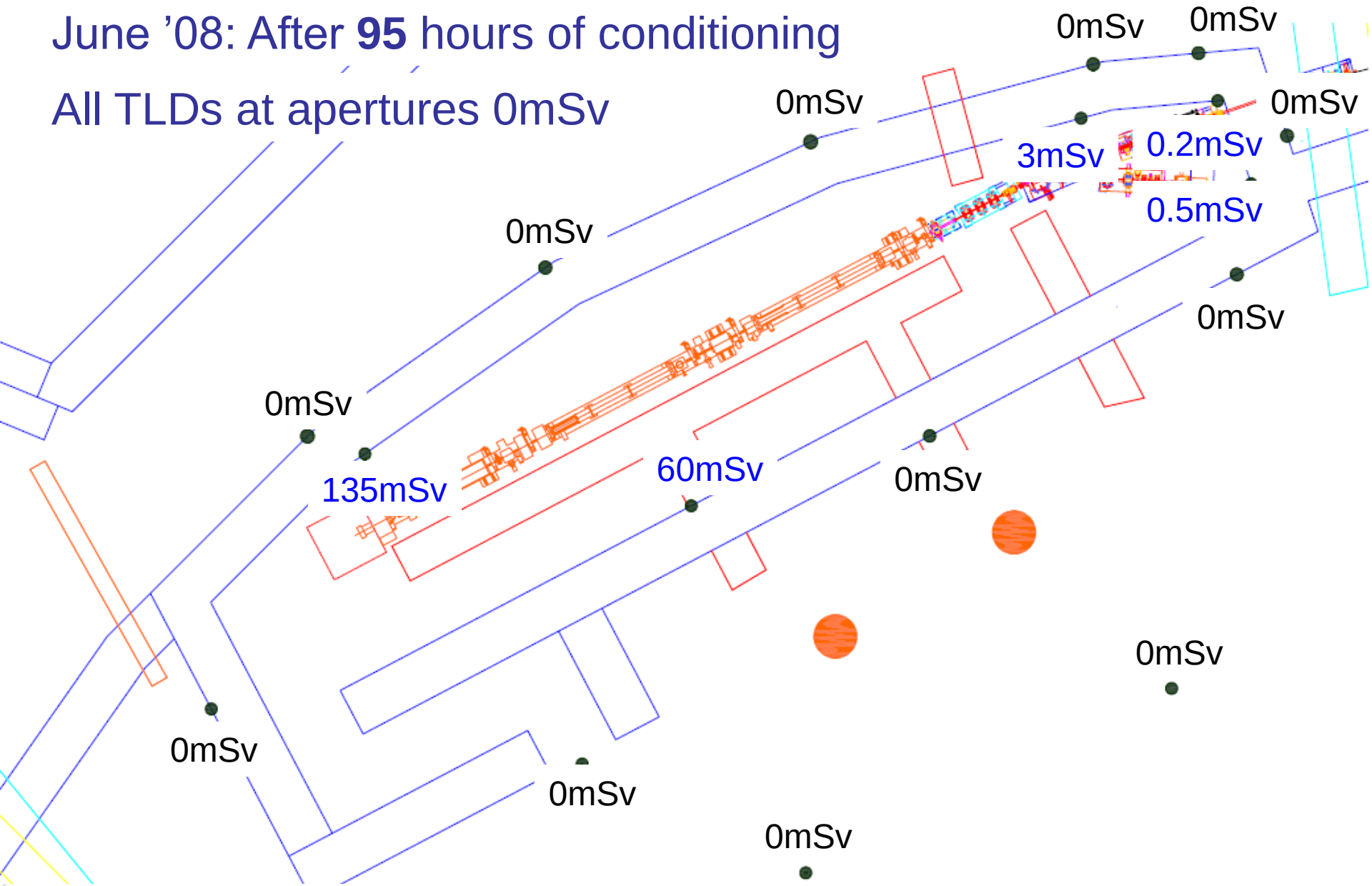
3a. TLD LOCATION

12 different TLD points NOT @ 140 cm

3a. TLD DATA: RF CONDITIONING

June ’08: After **95** hours of conditioning

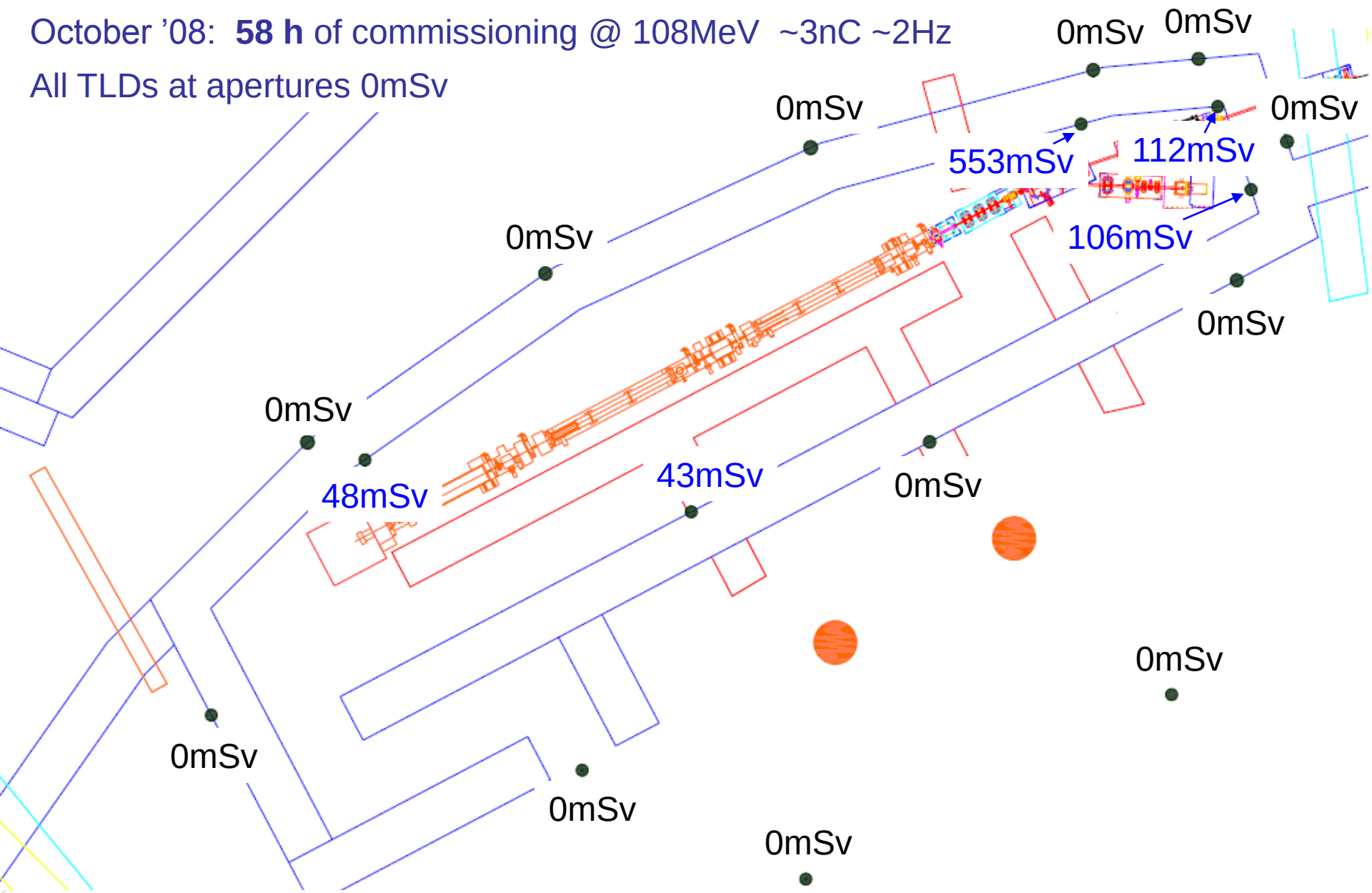
All TLDs at apertures 0mSv



3a. TLD DATA: MAXIMUM ENERGY

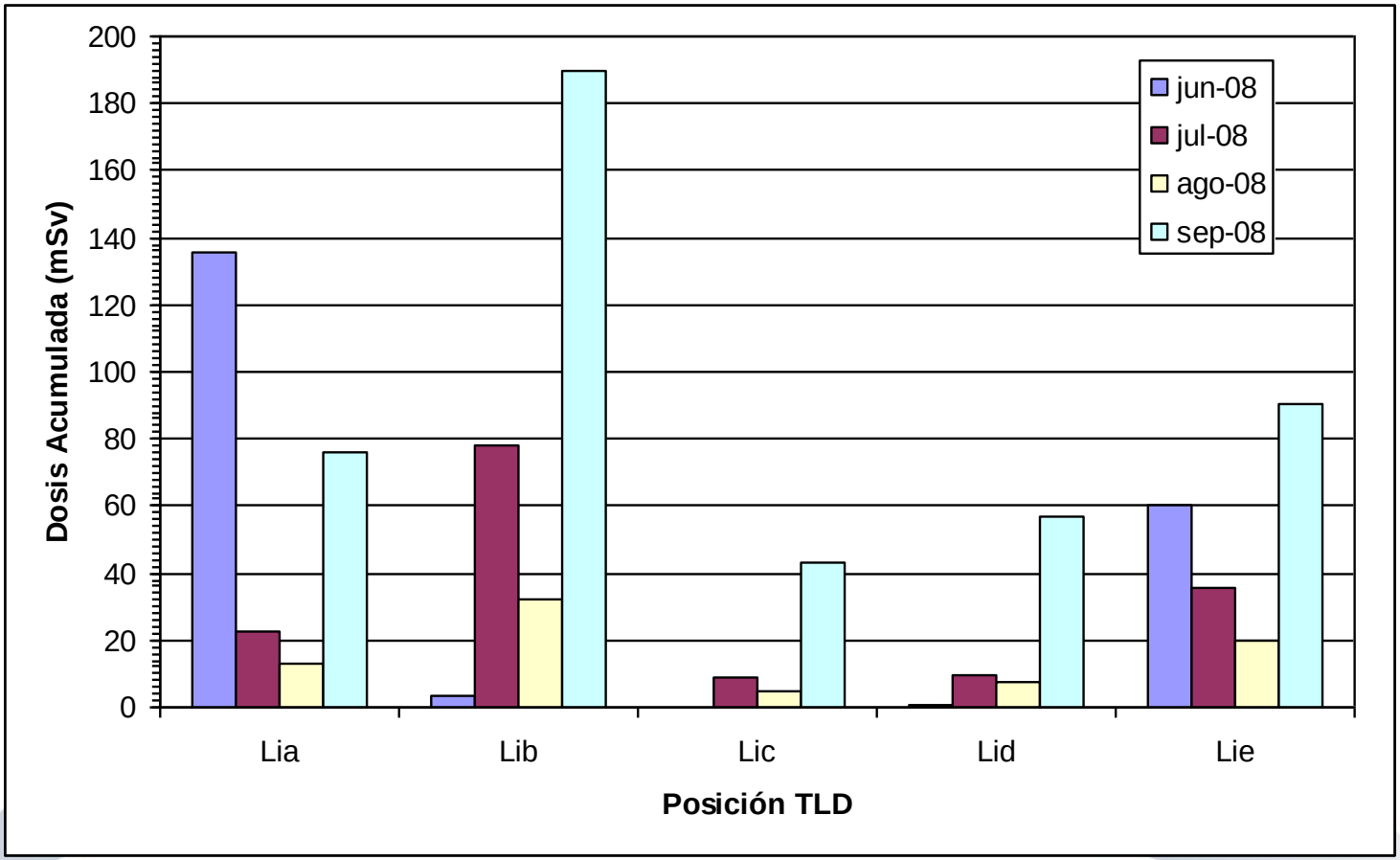
October '08: **58 h** of commissioning @ 108MeV ~3nC ~2Hz

All TLDs at apertures 0mSv



3a. TLD DATA: SUMMARY

- TLDs data **inside the bunker** by month:



- All the other TLDs have measured 0 mSv

3b. PORTABLE DETECTORS

DOSE RATE
<0.5 µSv/h

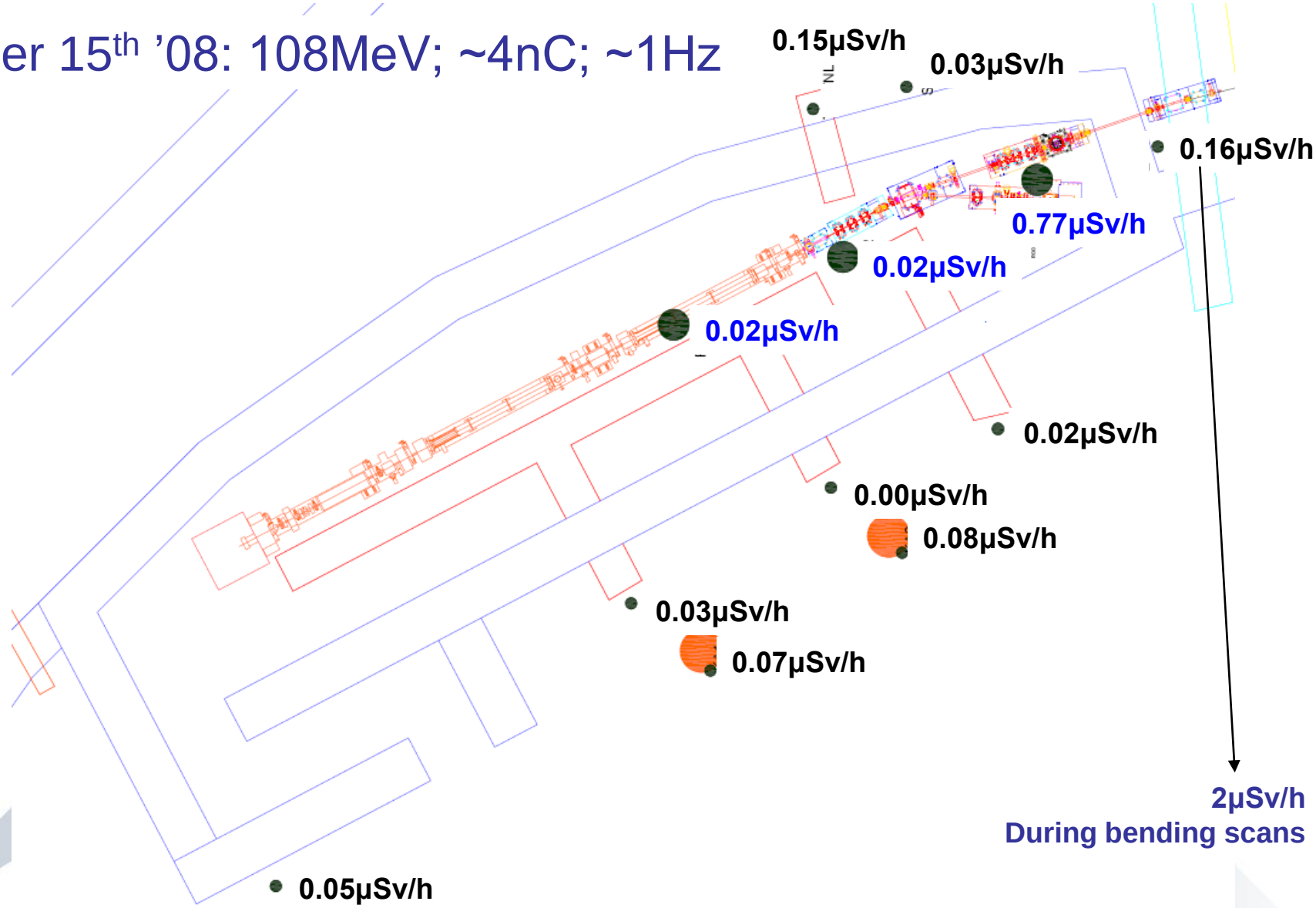
a. Control Room
   i. Trenches
   ii. Door
   iii. RF labyrinth
   iv. Alignment Windows
b. Roof (~***3µsv/h***)
c. Tunnel (*front wall* ~***2µsv/h***)
   i. Alignment Windows
   ii. Trenches

3b. PORTABLE DETECTORS: SPECS

COMPANY	MODEL	ENERGY RANGE	DETECTION RANGE
THERMO	SmartION Mini 2100S	>10keV	0-500mSv/h
FLUKE	Victoreen 451P	>25keV	<50mSv/h
THERMO	FH40 G-L10	>30keV	10nSv/h - 100mSv/h
THERMO	FHZ 672 E-10:	48 keV - 4.4 MeV	1nSv/h - 100mSv/h
THERMO	RadEye PRD	30 keV – 1.3 MeV	0.01 µSv/h – 250 µSv/h
THERMO	FHT 752 SH		0.01 - 100,000 cps
THERMO	RadEye N		>0.005 cps

3b. PORTABLE DETECTORS: DATA

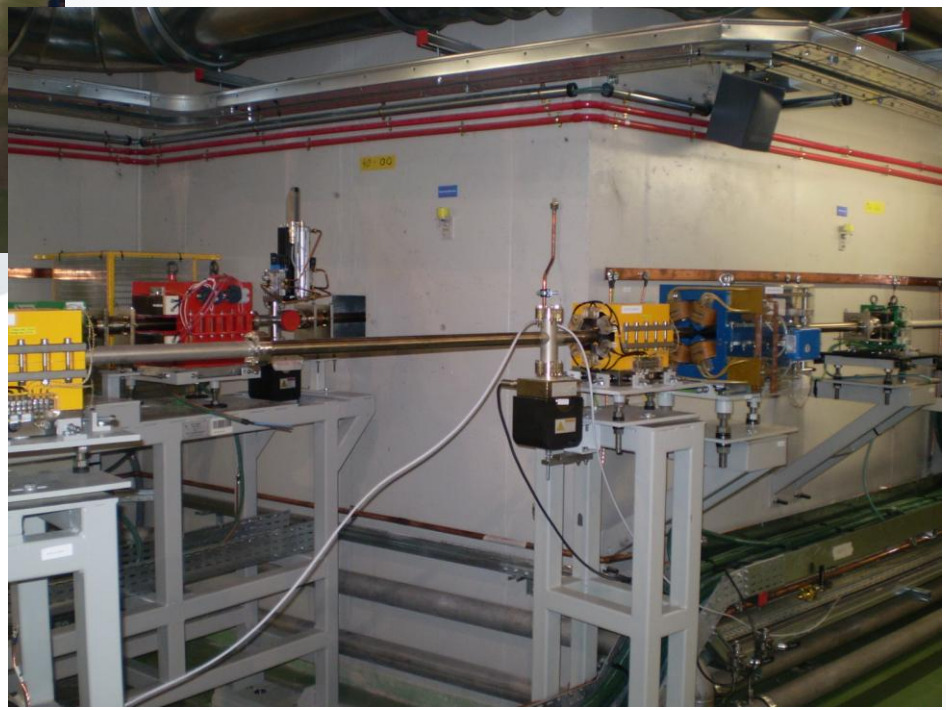
October 15th '08: 108MeV; ~4nC; ~1Hz



3b. DATA @ KLYSTRONS

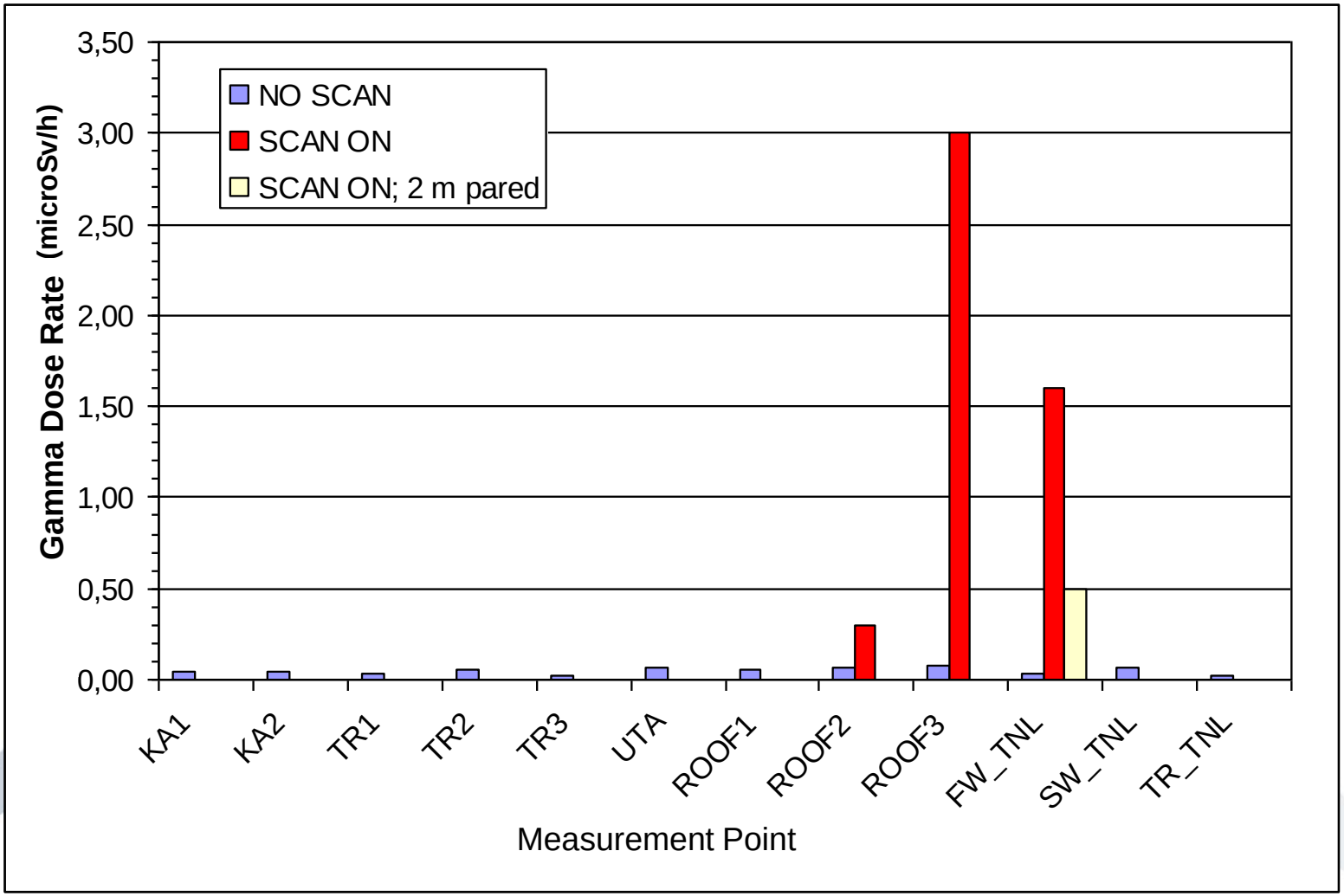
3b. PORTABLE DETECTORS: RESTRICTIONS

3b. PORTABLE DETECTORS: TODAY



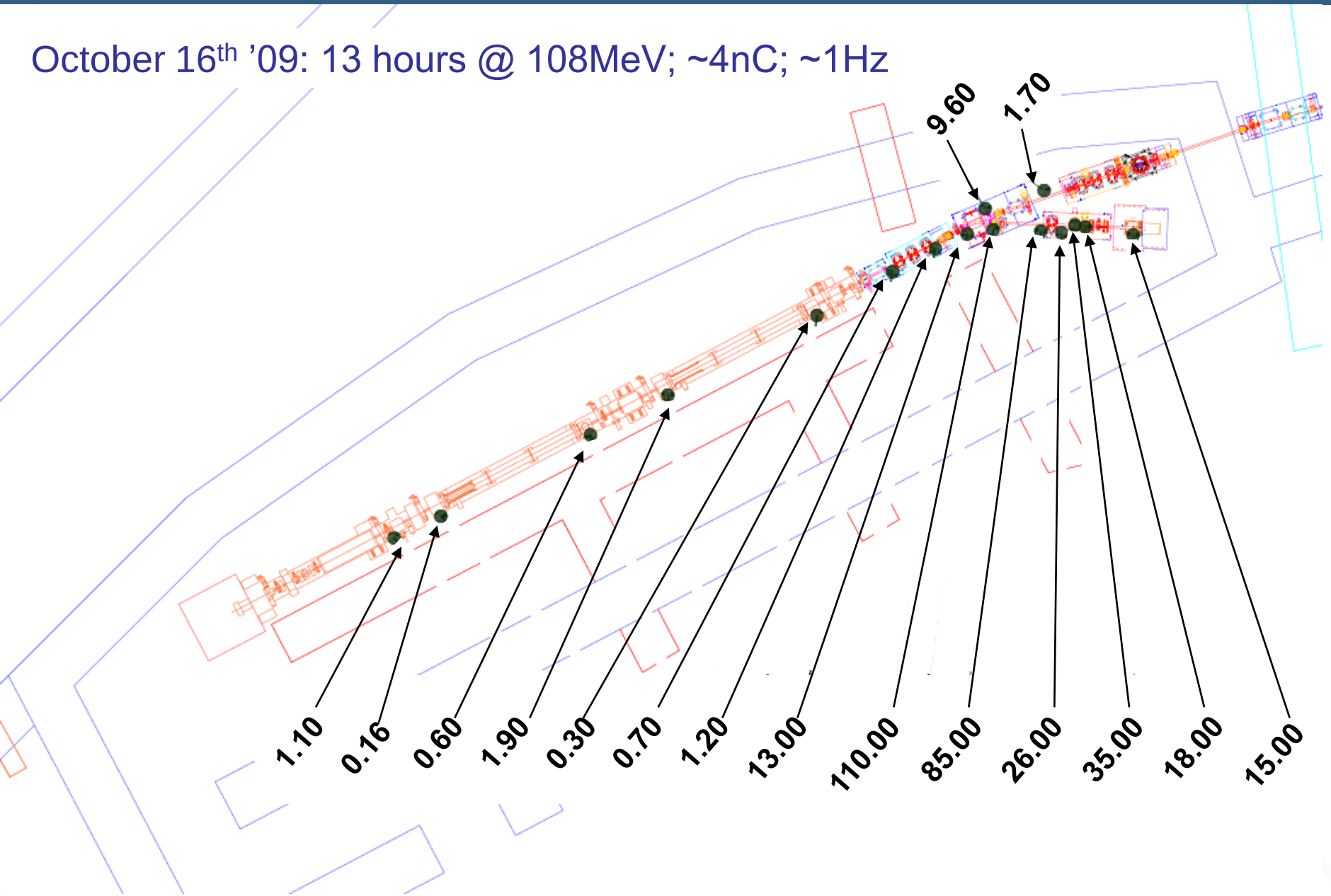
3b. PORTABLE DETECTORS: AREAS DATA

Portable detector measurements for the Sep 26th '08, for different locations outside the bunker



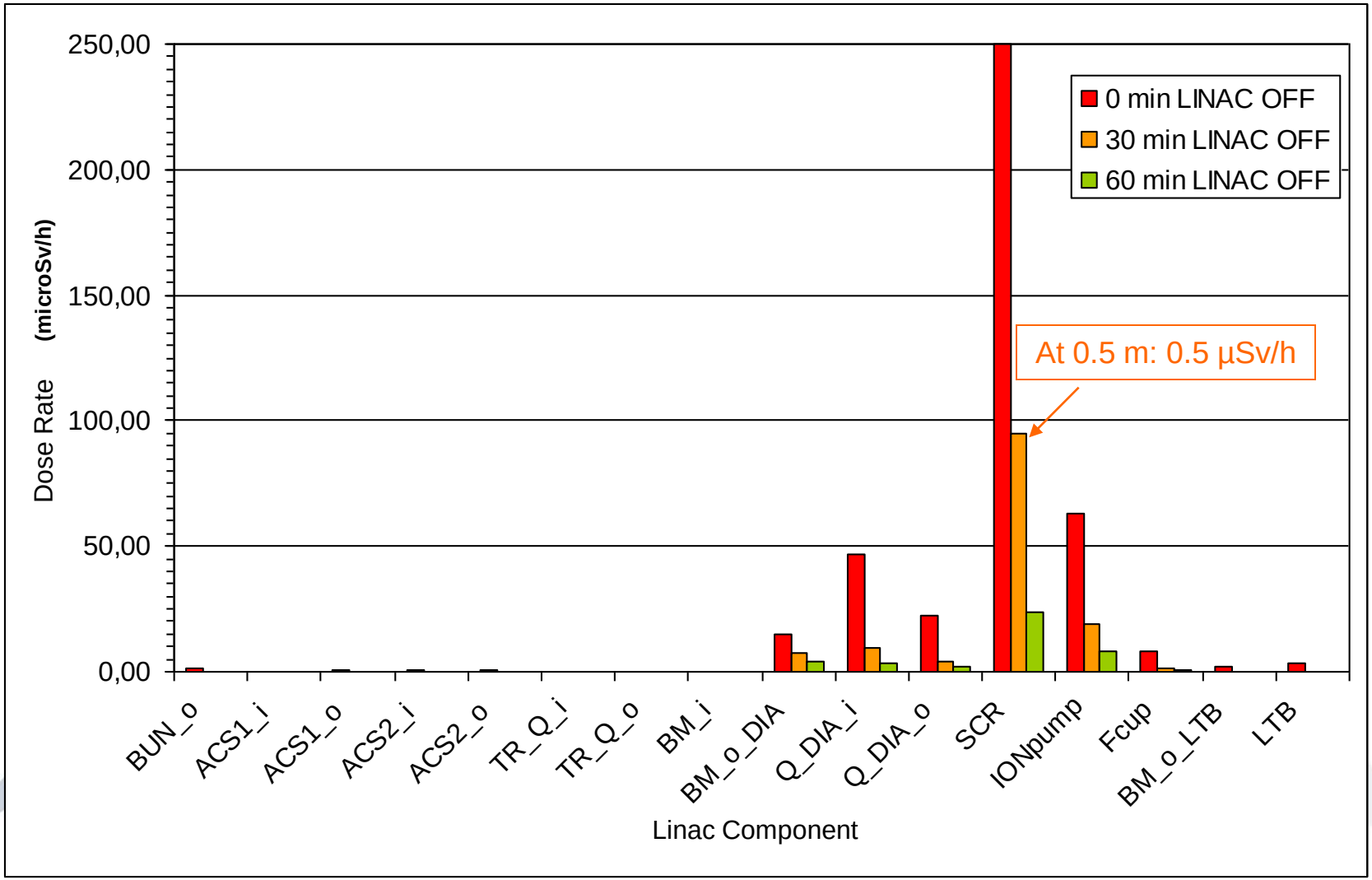
3b. PORTABLE DETECTORS: ACTIVATION

October 16th '09: 13 hours @ 108MeV; ~4nC; ~1Hz



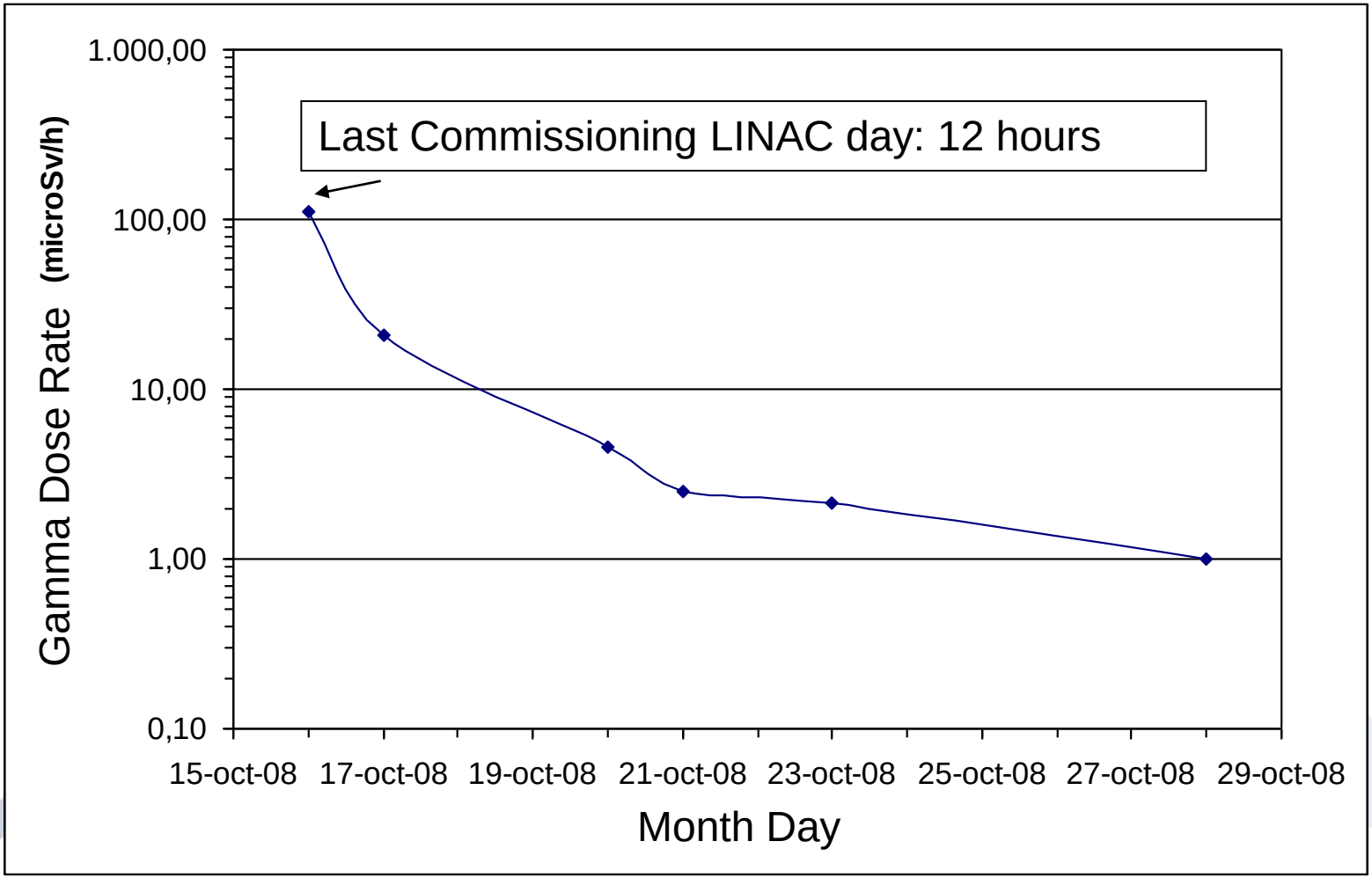
3b. PORTABLE DETECTORS: ACTIVATION

Measurements on surface (Sep 26th '08):



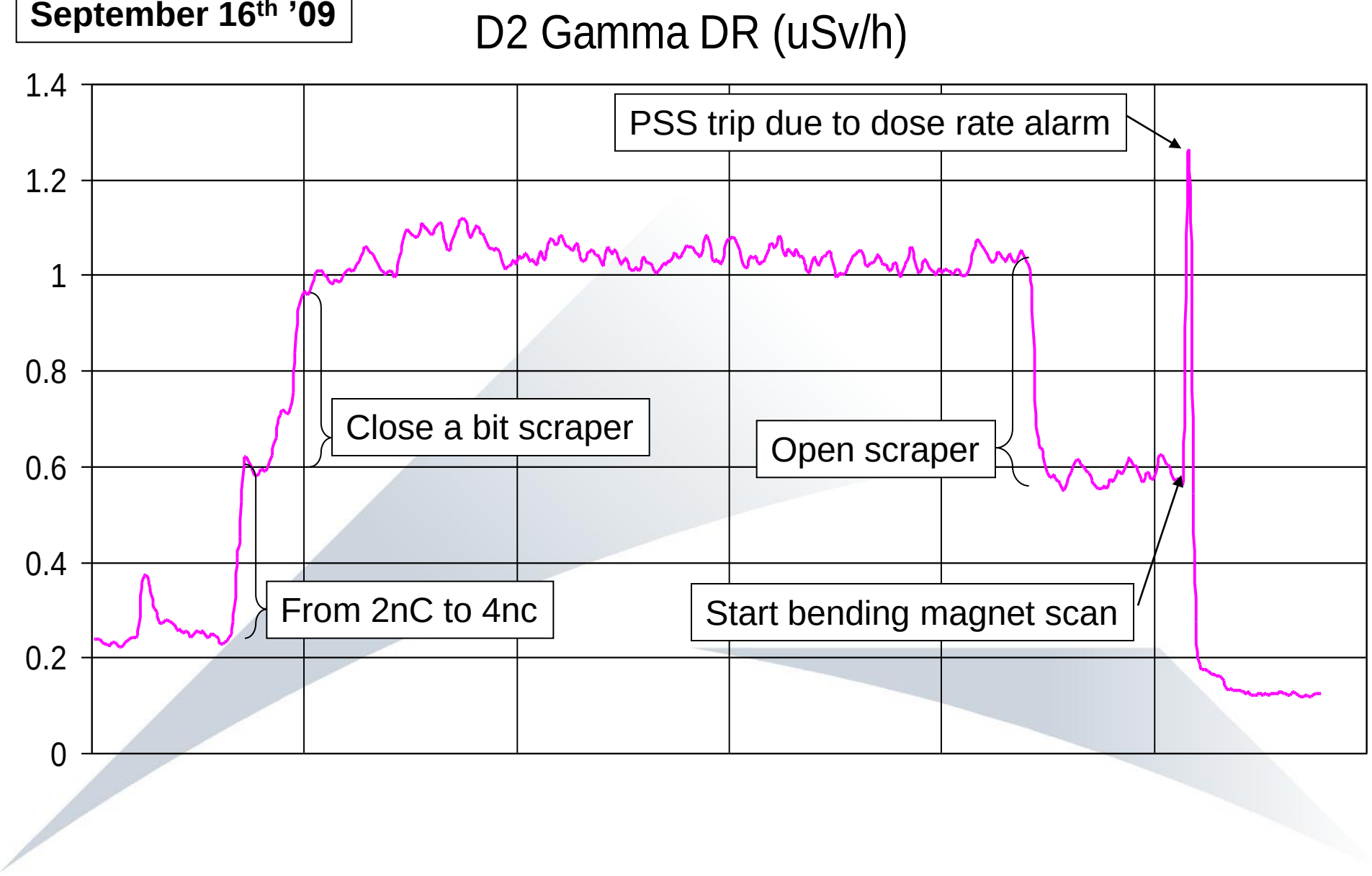
3b. PORTABLE DETECTORS: ACTIVATION

Gamma dose rate at the BM vacuum chamber exit



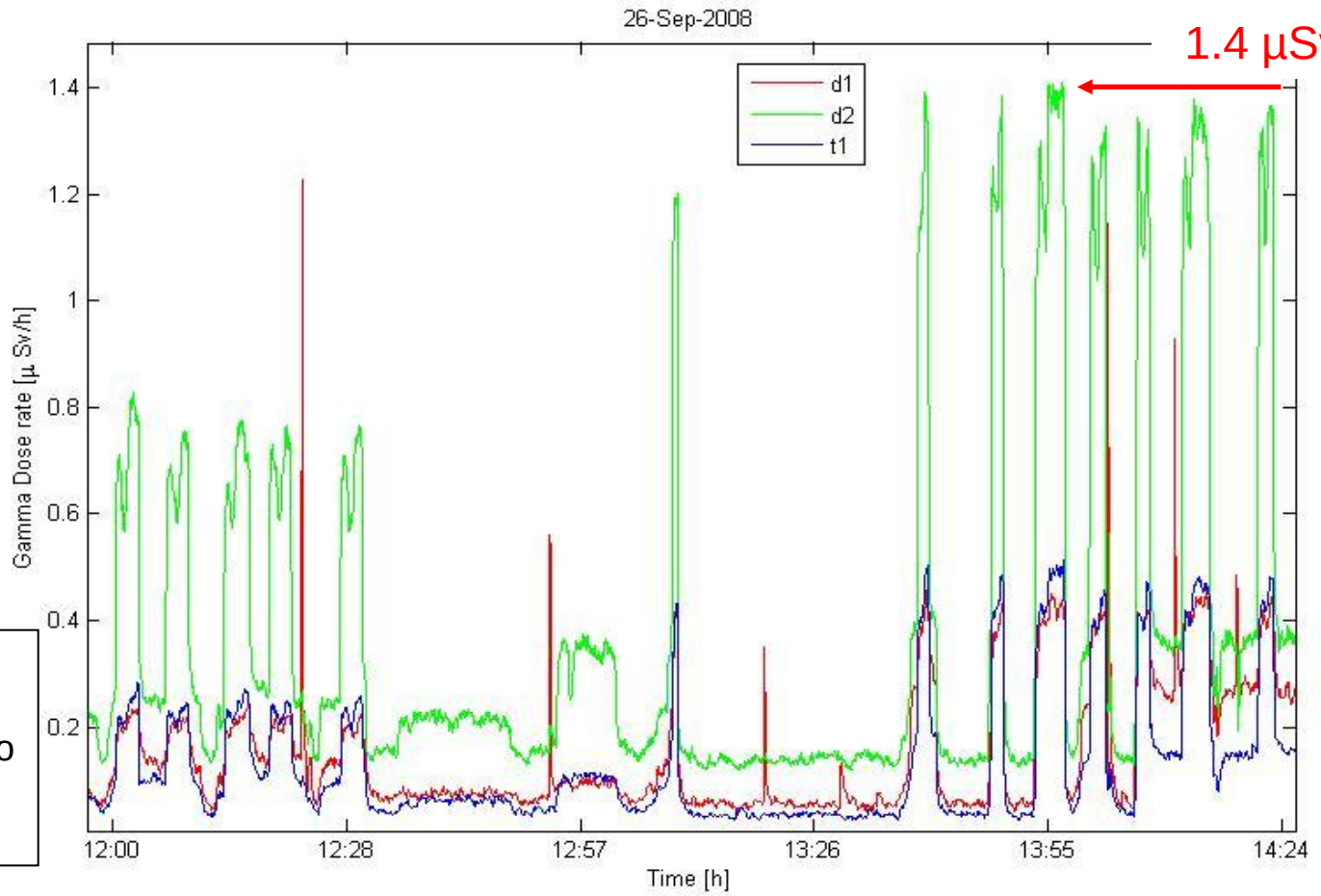
3c. Radiation Monitors Network-RMN

September 16th '09



3c. RMN: Cu SCRAPPER DATA

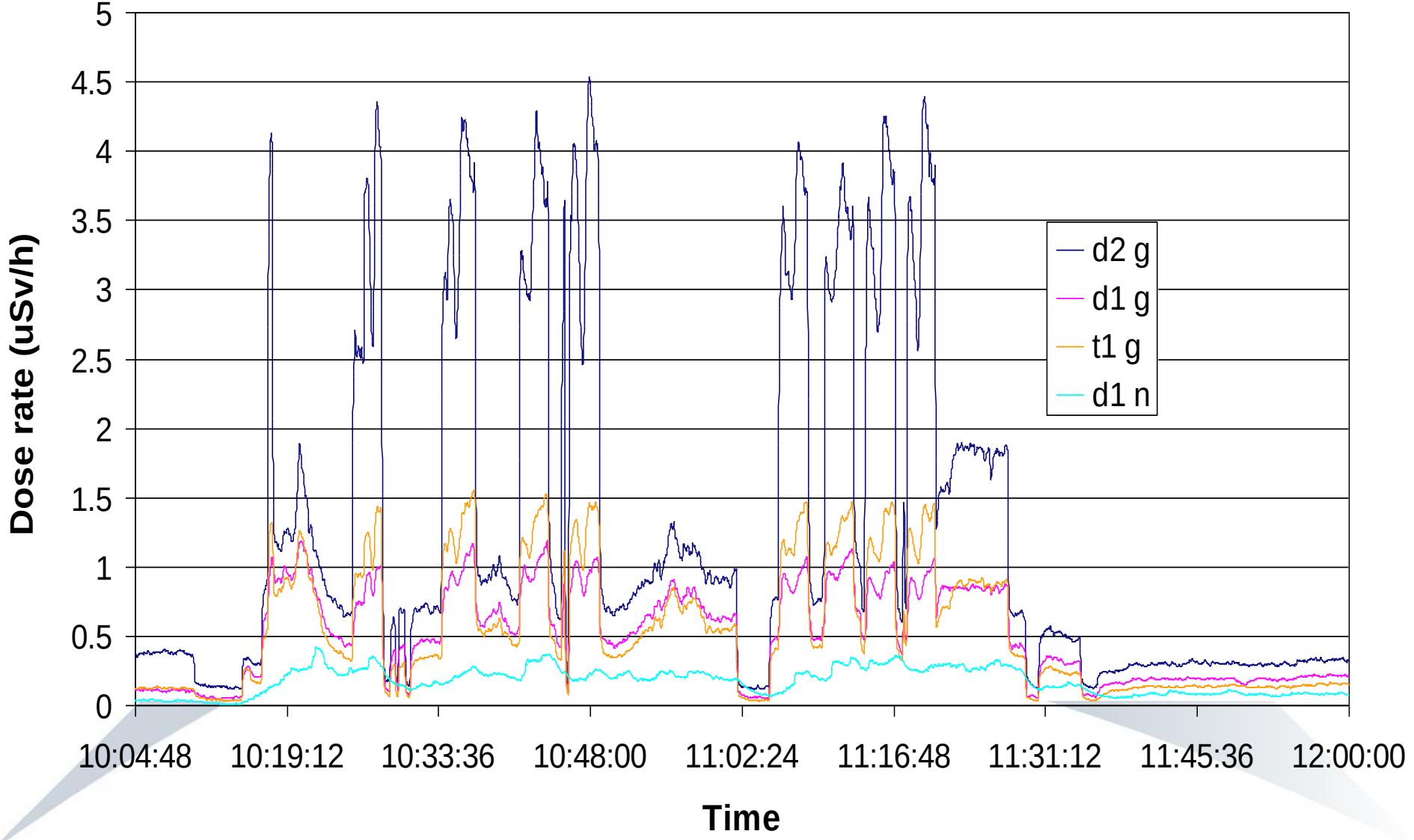
Gamma dose rate due to the Cu scrapper scans



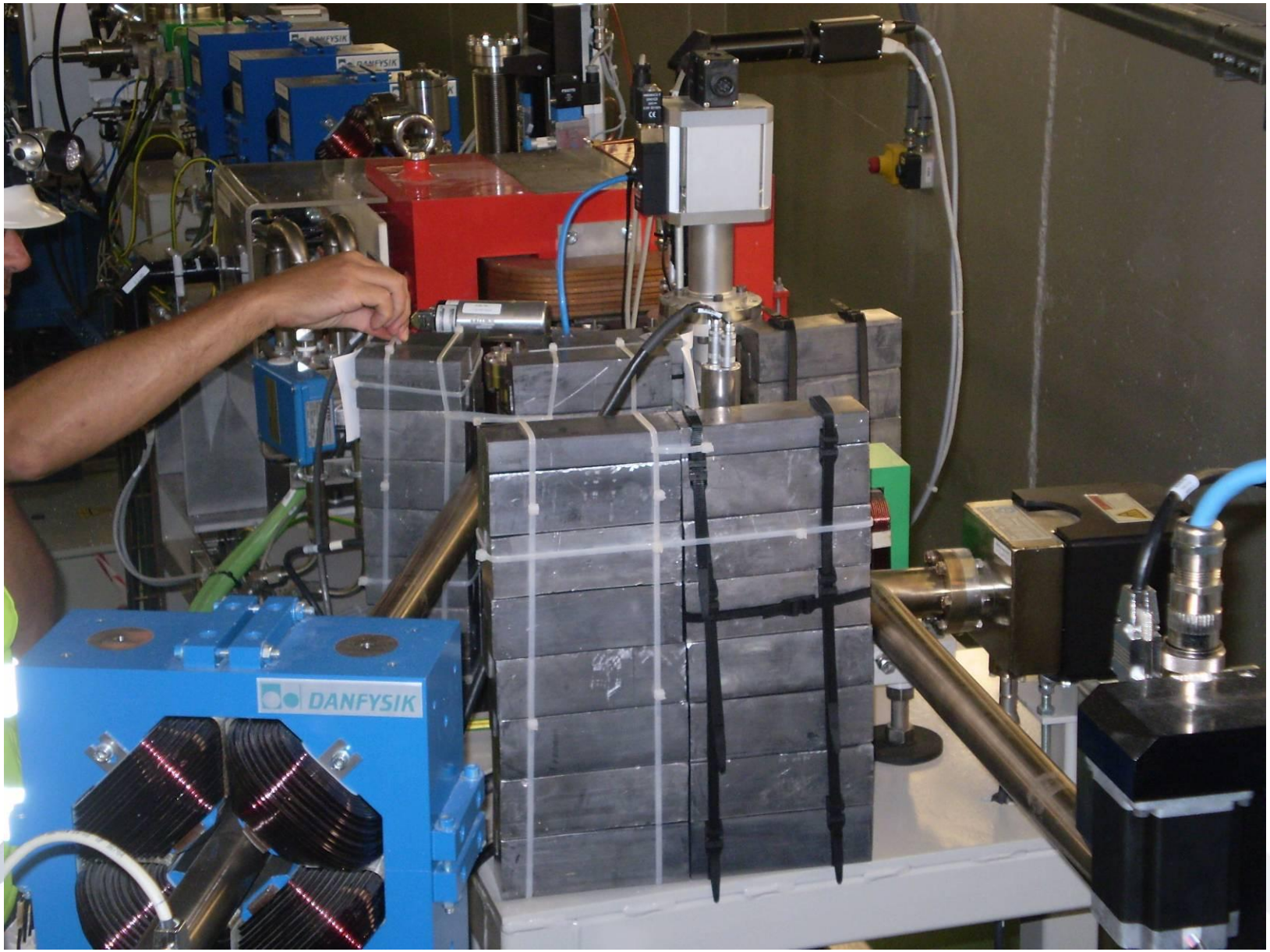
26-Sep-2008
SCRAPER SCANS
Charge/pulse: 4nC/pulso
Energy: 109MeV
Frequency: 1Hz

3c. RMN: Cu SCRAPPER DATA

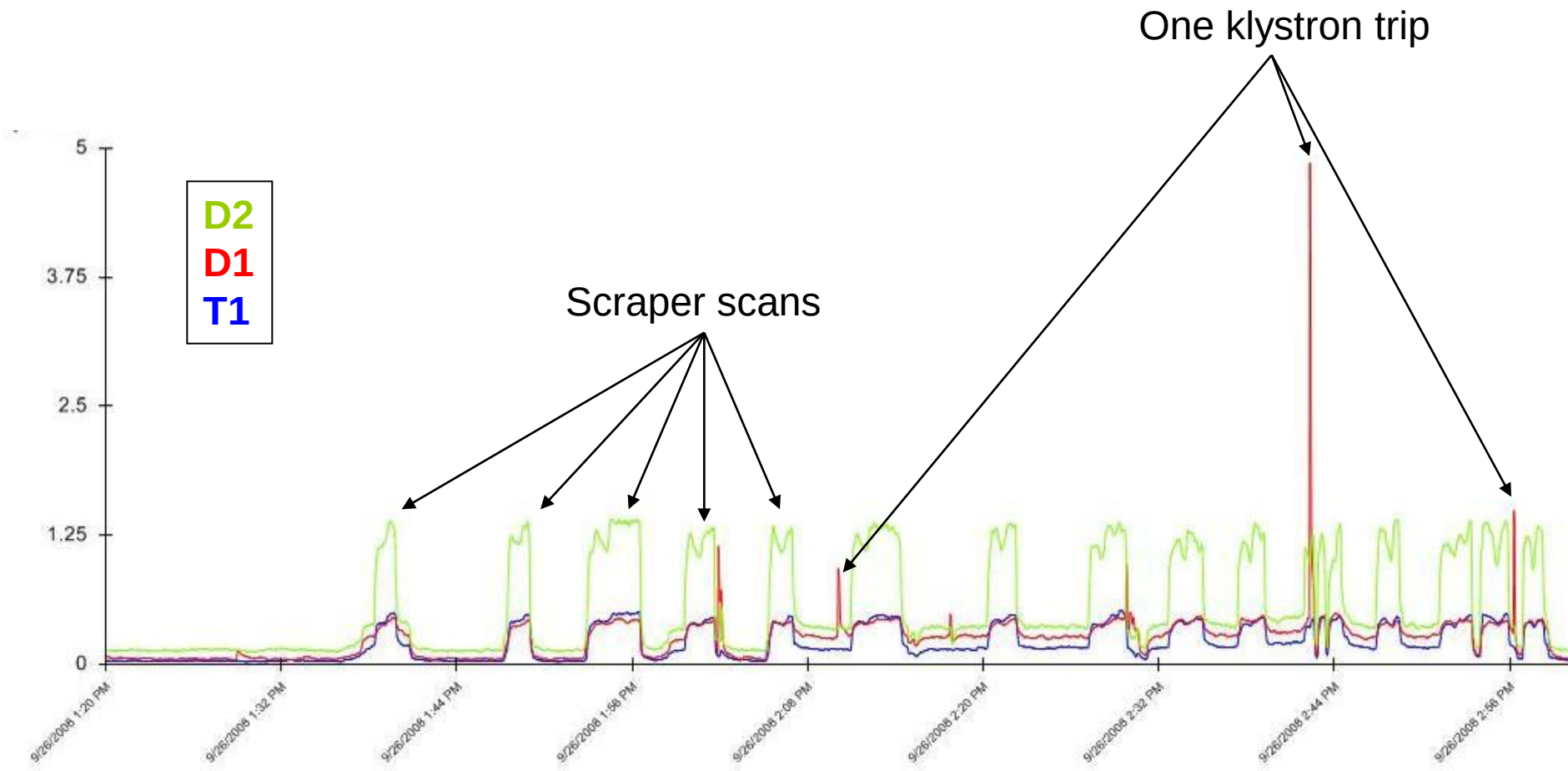
October 2nd '09



3c. RMN: LOCAL SHIELDING

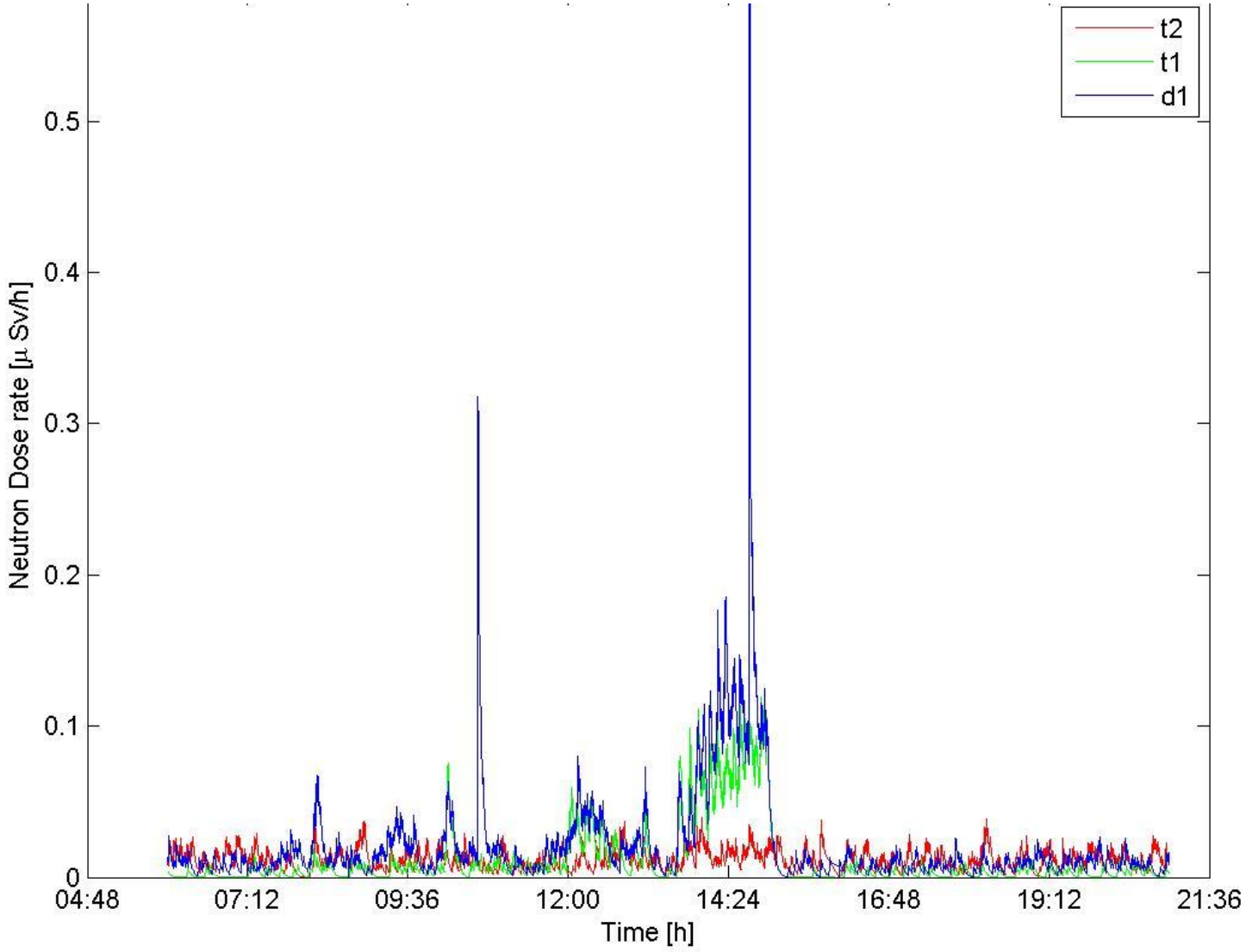


3c. RMN: LOCAL SHIELDING EFFECT



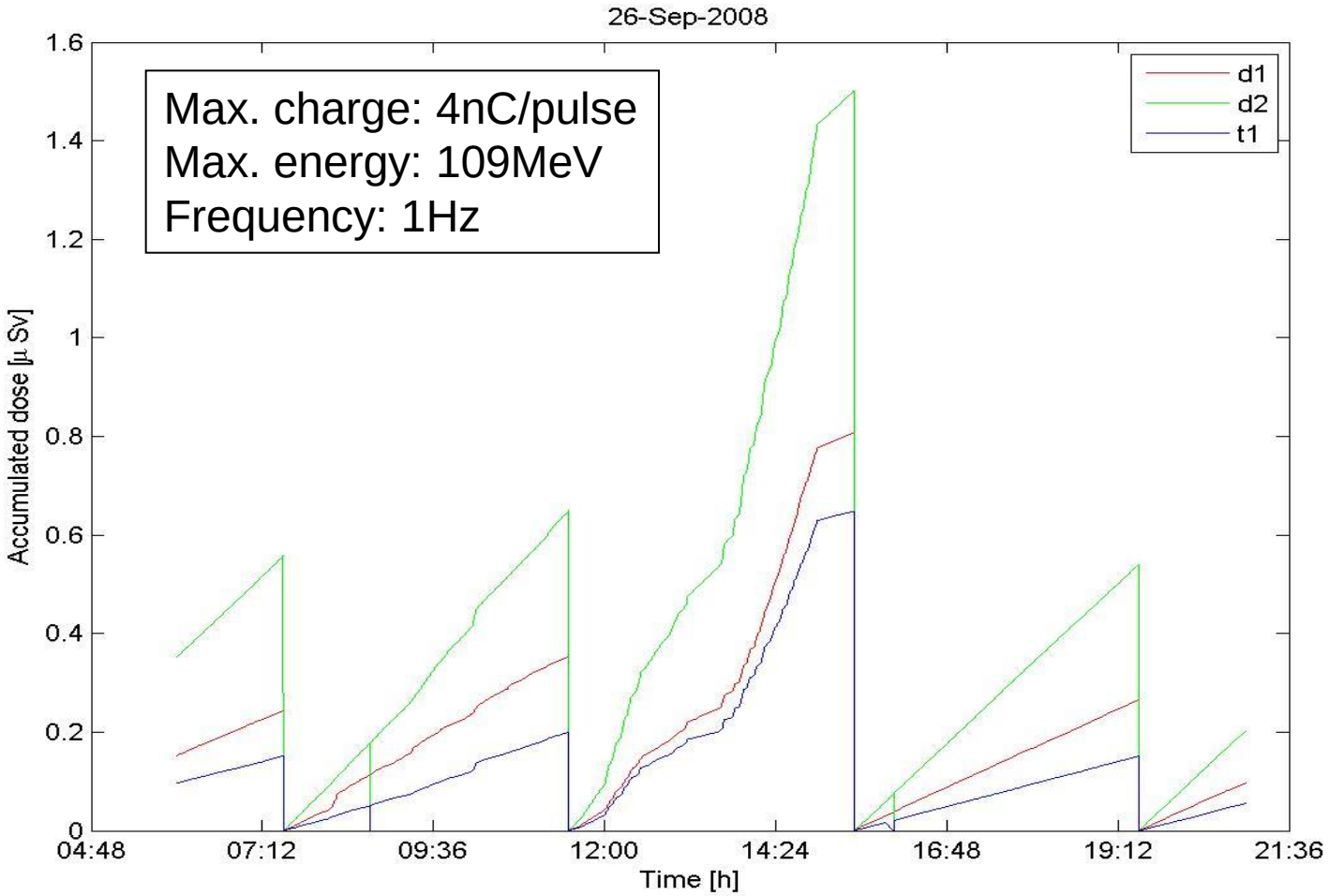
3c. RMN: NEUTRON SCRAPPER DATA

Neutron dose rate due to the Cu scrapper scans

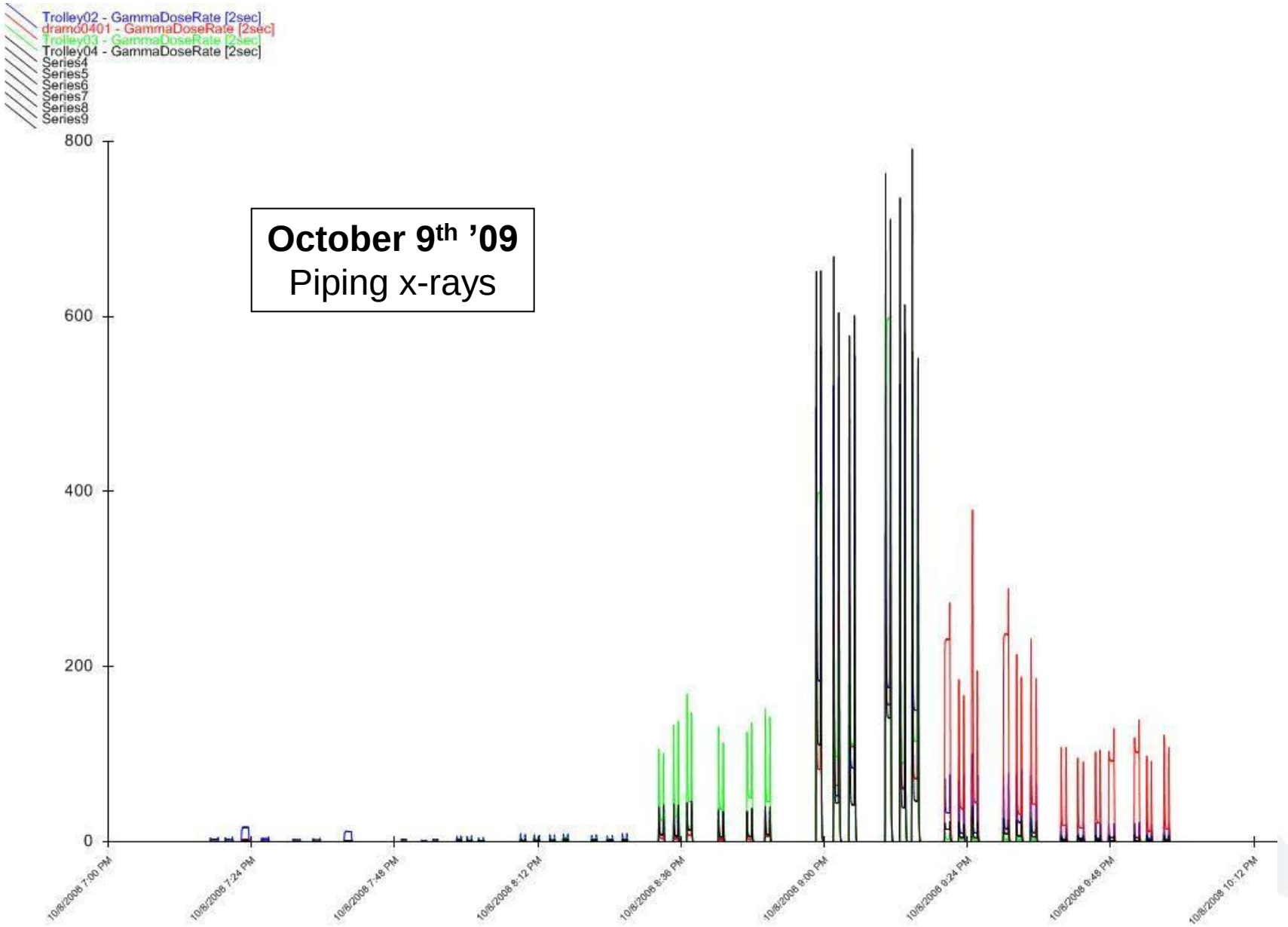


3c. RMN: ACCUMULATED DOSE

Total accumulated dose (maximum values):



3c. RMN: “OTHER” MEASUREMENTS



4. NEXT STEPS

1. Re-start the ALBA linac: Sep'09
2. Recover the previous linac values with the final services
3. Install 2 local screens to reduce the external dose during commissioning
4. Foreseen linac shifts dedicated for Radiation Measurements
5. Make a correlation between gamma&neutron DR
6. Add an interlock signal to the BM

ACKNOWLEDGEMENTS

- ✓ Thales Company: D.Jousse and A.Setty
- ✓ ALBA Accelerator Division: D. Einfeld team
- ✓ ALBA Control&Computing Division: J. Klora team
- ✓ Radsynch Colleagues
- ✓ Radsynch Organization

✓*Many Thanks!*